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A COMPUTER PROGRAM FOR SCHEDULING ALLOWABLE CUT USING EITHER AREA OR VOLUME REGULATION DURING SEQUENTIAL PLANNING PERIODS

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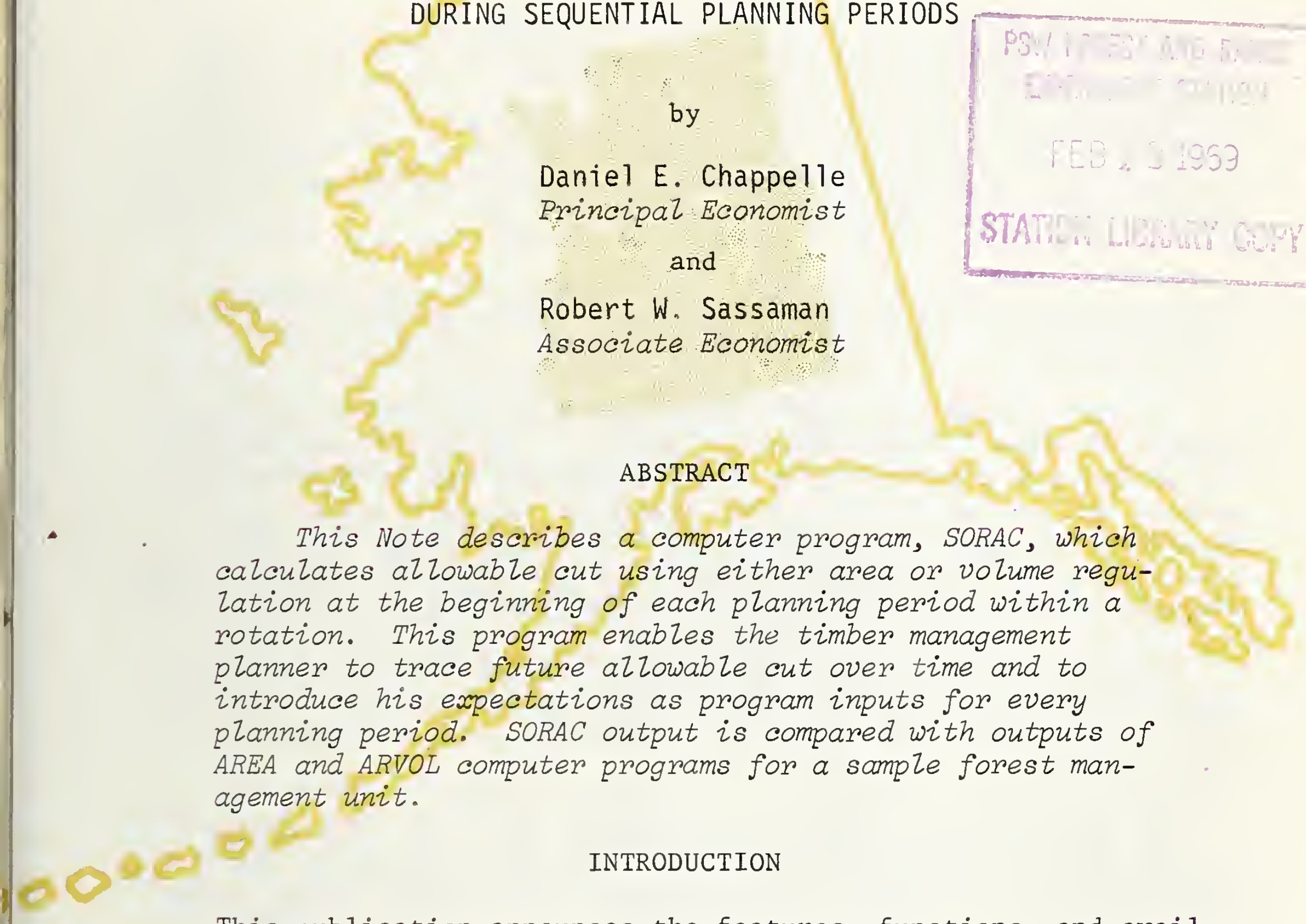

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ABSTRACT

This Note describes a computer program, SORAC, which calculates allowable cut using either area or volume regulation at the beginning of each planning period within a rotation. This program enables the timber management planner to trace future allowable cut over time and to introduce his expectations as program inputs for every planning period. SORAC output is compared with outputs of AREA and ARVOL computer programs for a sample forest management unit.

INTRODUCTION

This publication announces the features, functions, and availability of the SORAC computer program, developed in connection with a study of timber management planning on the Pacific Northwest National Forests. This program simulates the process that forest managers commonly use in planning the allowable cut.

Timber harvest scheduling is one of the most challenging decisions facing forest managers today as the demand for timber increases along with pressure for alternative land uses. In the Douglas-fir region of the Pacific Northwest, managers of National Forest timberlands have seen actual cuts rise to equal planned or allowable cuts. In such a pressurized managerial environment, it is important that timber production scheduling be efficiently handled and integrated into the total decisionmaking system as smoothly as possible.

Traditionally, timber harvest scheduling has been accomplished by manual calculation with either the volume or area regulation method. Manual calculation of allowable cut is both extremely time consuming and error propagating. This is especially true of the volume regulation method which determines cut through an iterative procedure.

Computer simulation models, including AREA, ARVOL, and SORAC,[1] were recently developed to facilitate calculating allowable cut by these traditional methods. ARVOL[2] permits the analyst to quickly and accurately examine allowable cut under a range of conditions, assuming volume regulation, and AREA[3] provides similar facility in the case of area regulation. This Note assumes that volume regulation and the area-volume check method are synonymous.

Although the ARVOL and AREA computer programs can more rapidly, accurately, and comprehensively calculate annual allowable cut than previous methods, traditional approaches to timber harvest scheduling do not realistically simulate the management decision process over time.

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[1] ARVOL, AREA, and SORAC are products of the Timber Management Decision Systems (TIMADS) study. TIMADS, a continuing cooperative research effort of the Pacific Northwest Forest and Range Experiment Station and the Pacific Northwest Region of the Forest Service, U.S. Department of Agriculture, is a long-term study designed to provide forest managers with a more effective planning system. None of these programs include intermediate cuts in the allowable cut totals.

[2] Chappelle, Daniel E. A computer program for calculating allowable cut using the area-volume check method. Pacific Northwest Forest & Range Exp. Sta. U.S.D.A. Forest Serv. Res. Note PNW-44, 4 pp. 1966.

[3] Sassaman, Robert W., and Chappelle, Daniel E. A computer program for calculating allowable cut using area regulation and a comparison with the ARVOL method. Pacific Northwest Forest & Range Exp. Sta. U.S.D.A. Forest Serv. Res. Note PNW-63, 7 pp. 1967.

Traditional regulation methods, including those simulated by ARVOL and AREA, are one-time, static approaches to a dynamic planning situation. However, in practice, National Forest timber management plans are revised periodically. Hence, the allowable cut decision is evaluated periodically during a rotation or conversion period. On the west side of the Cascade Range, either area or volume regulation is applied in every planning period[4] to the most recent working circle data. During these reevaluations, various parameters of the planning model are updated (e.g., timber yields, rotation length, etc.). Parameter values may change from planning period to planning period because either actual conditions will have changed or managers will have expectations of change.

Also, the traditional regulation models assume a fixed investment horizon, whereas decisionmaking operates within a constantly changing investment horizon. Forest managers have recognized this constantly changing investment horizon in their adoption of such policies as sustained yield and multiple use. These policies constrain the range of management alternatives, although no computer models have been available to show the implications of these constraints.

The development of SORAC[5] is a step toward a continuous, computerized, forest management, decisionmaking system, as it combines a continuously changing time horizon with frequent policy reevaluation. SORAC calculates the allowable cut for each planning period and thereby provides the opportunity to incorporate effects of expected management changes into the allowable cut decision process within a rotation.

With SORAC, forest managers can introduce their expectations for every planning period within a rotation, thereby permitting them to test various management strategies and facilitating the selection of strategies most likely to fulfill the goals of the firm. In contrast, the AREA and ARVOL computer models, as generally used, do not simulate the timber harvest scheduling process because they permit the analyst to introduce expected management and environmental changes only at the beginning of a rotation.

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[4] Planning period is defined as the interval of time in which parameters of the planning model (e.g., yield equation coefficients) do not change in value. This may also be thought of as the interval between regular management plan revisions. A decade is a common planning period in the Pacific Northwest.

[5] The acronym, SORAC, was derived from the words "ShOrt Run Allowable Cut." The method of analysis is considered shortrun since planning is done sequentially, planning period by planning period, by rather short intervals.

DESCRIPTION OF SORAC

SORAC Features

The SORAC program is coded in FORTRAN IV. Program characteristics include:

1. Forecasts annual allowable cut for each planning period within a rotation. The length and number of planning periods to be examined are selected by the analyst.

2. Provides a choice of using either area or volume regulation within each planning period.

3. Allows the analyst to specify the volume unit; e.g., board feet, cubic feet, etc.

4. Provides for automatic updating of data at the end of a planning period for use in the next allowable cut calculation, if desired.

   If automatic update is not desired, then new data must be read.

   If automatic updating of data is desired, all parameters continue at previous levels and the rotation age must be evenly divisible by the planning period.

5. Provides the advantage of dealing in value as well as volume by introducing stumpage prices into the allowable cut calculations.

6. Has the flexibility of using a separate empirical yield equation for each stand, whether intensively or extensively managed.

7. Has capacity for analyzing a maximum of 80 stands[6/] in one problem.

8. Allows a separate yield equation for intensively managed stands to be entered for each stand or allows entering a normal yield equation for use in conjunction with empirical yield equations for extensively managed stands.

[6/] In this discussion, an age class is generally considered to be a stand. However, it is possible that several stands can be the same age.

9. Allows both extensively and intensively managed stands to be included in all analyses.

10. Recognizes that regeneration period is an input and hence may be varied as desired by the analyst. Negative age classes may be assigned in those cases where a period longer than the assumed regeneration period is likely to occur.

11. Permits stacking of problems; i.e., a number of analyses may be completed in one computer run.

Some analysts will wish to replace previously released ARVOL and AREA computer programs with SORAC, because analyses which may be completed by ARVOL or AREA may be handled by selecting various SORAC options. However, SORAC can accomplish much more than ARVOL or AREA, as noted above. Program characteristics 1-8 are unique to SORAC as contrasted to ARVOL and AREA.

INPUTS

1. Number of problems to be run.
2. Problem title.
3. Stand regeneration indicator (i.e., an indicator as to whether zero-age stands are regenerated or bare).
4. Trial allowable cut, volume unit.
5. Number of stands.
6. Beginning year of planning horizon.
7. Ending year of planning horizon.
8. Volume unit title.
9. Age of stands.
10. Area distribution by stands, acres.
11. Physical input control for yield equation coefficients and for the percentage of area intensively managed.
12. Stumpage price input control.
13. Cut regulation method control (i.e., either volume or area regulation).
14. Rotation, years.
15. Planning period, years.
16. Minimum cutting age, years.[7]
17. Regeneration period, years.
18. An identifier that specifies which yield equations are to be used for intensively managed stands.
19. Coefficients of price equations for extensively and intensively managed stands.
20. Coefficients of empirical yield equations for extensively managed stands.
21. Coefficients of yield equations for intensively managed stands and percentage of area intensively managed.

    Or

    Normal yield coefficients, the number of the first intensively managed stand, and the percentage of area intensively managed.
22. Yield multiplier, a constant percentage increase in previous physical yield.
23. An addition to the percentage of area intensively managed for each stand, if desired.
24. An end-of-problem indicator.

OUTPUTS

Outputs 1 through 10 are listed for each stand. Outputs 11 through 20 are aggregates of stand values:

1. Acreage.
2. Average age when cut, years.
3. Yield per acre when cut, volume unit.
4. Total yield when cut, volume unit.
5. Time required to cut the total yield, years.
6. Cumulated time required to cut the total yield, years.
7. Area to cut annually, acres (assuming volume regulation) or average volume to cut annually (assuming area regulation), volume unit.
8. Area intensively managed, percent of total area.
9. Average price, dollars per thousand volume units.
10. Total value of yield, dollars.
11. Total area, acres.
12. Total volume, volume unit.
13. Total value of rotation harvest, dollars.
14. Average annual allowable cut during planning period, volume unit.
15. Average area cut per year, acres.
16. Average yield per acre, volume unit.
17. Average yield per acre per year, volume unit.
18. Regeneration period, years.
19. Area cut (acres) each year of the rotation assuming volume regulation.

    Or

    Volume cut each year of the rotation assuming area regulation.
20. Value of timber harvested each year of the rotation, dollars.
21. Value of average annual allowable cut during period.

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[7] Minimum cutting age is not a constraint. It is simply a more accurate starting point than stand age for the procedure used to determine the number of years required to cut any given stand under the volume regulation option. Therefore, it is possible to calculate an average age-when-cut for a stand with lower than the minimum cutting age.

APPLICATION OF SORAC

An example of the use of SORAC and an illustration of how its output can differ from ARVOL and AREA outputs is illustrated for a sample management unit in figures 1 and 2. The stand structure for the sample management unit is shown in table 1. Note that the unit contains a predominance of overmature stands (in excess of rotation age of 90 years). The analyses discussed here were completed with identical data, and it was assumed that levels of management intensity and utilization standards remain constant throughout the entire period of 180 years (two 90-year rotations). Also, the oldest stands are assumed to be cut first in all cases.

Table 1.--*Stand structure of sample management unit at beginning of first planning period*

Age	Area	Age	Area
Years	*Acres*	*Years*	*Acres*
450	12,725	110	20,362
400	71,896	100	21,632
350	62,988	90	14,633
300	34,358	80	28,630
250	29,267	70	26,723
200	15,270	60	23,542
180	5,726	50	14,634
170	6,363	40	19,087
160	6,362	30	8,907
150	9,543	20	9,544
140	12,725	10	13,361
130	15,905	0	15,905
120	14,634		

In figure 1, annual allowable cut is shown for each year of the period for SORAC (volume regulation option), ARVOL, and AREA. SORAC and ARVOL assume volume regulation, but AREA assumes area regulation. Figure 1 indicates the effect of one characteristic of SORAC; namely, that the program always looks ahead a period of time equal to one rotation when allowable cut is calculated. For example, the cut during the first planning period (years 0-10 of the first rotation) is calculated with a goal of even flow during the entire first rotation (years 0-90), whereas the cut during the second planning period is based on years 10-100 (i.e., looking ahead to the end of the first planning period of the second rotation), etc. It is this characteristic that causes the SORAC allowable cut trend line to significantly differ from

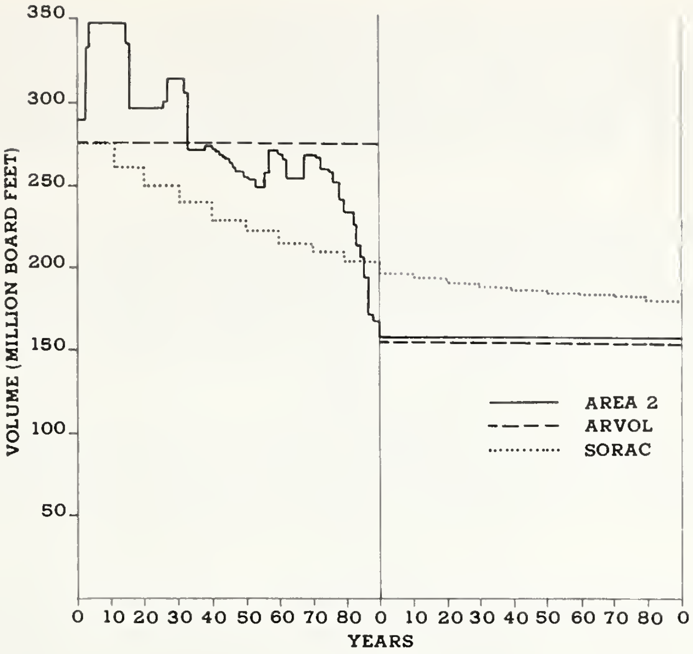

Figure 1.--Annual allowable cut determined with SORAC (volume regulation option) and a comparison with levels calculated with ARVOL and AREA.

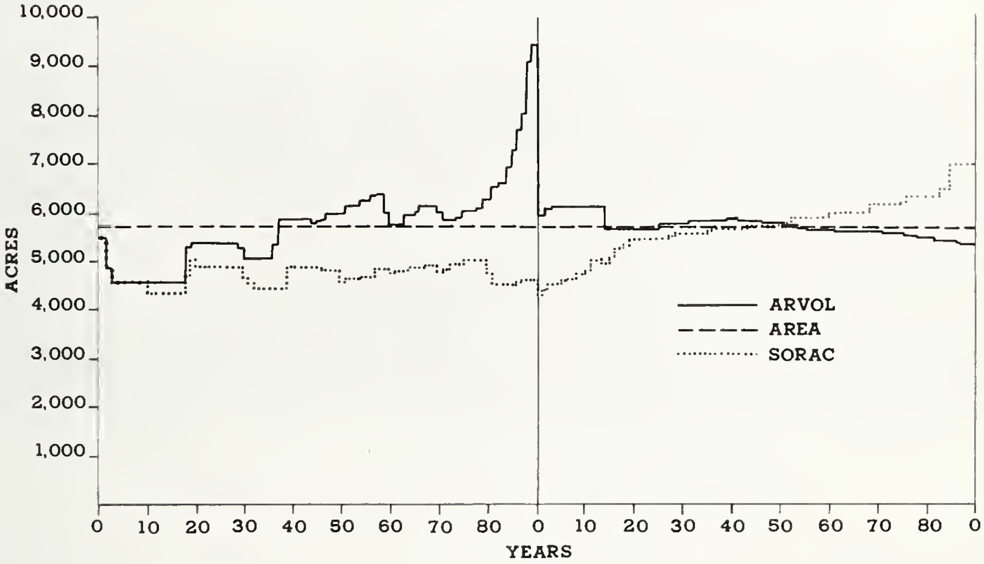

Figure 2.--Area cut annually determined with SORAC (volume regulation option) and a comparison with levels calculated with ARVOL and AREA.

the ARVOL line. Whereas ARVOL provides for the maintenance of even flow of timber during each rotation, the cut level during the second rotation is only approximately 60 percent of the first rotation cut. In contrast, the SORAC trend line declines more gradually, ending at year 180 with a cut nearly 70 percent of the first-year cut.

This effect occurs because the cut of overrotation-age timber (>90 years) is spread over a longer period of time than in the case of ARVOL; that is, the investment horizon is longer. In SORAC, the allowable cut is required to be even flow, but only within a planning period. Note that the SORAC level of cut during the first planning period is identical to that of ARVOL.

Figure 1 indicates that SORAC output, from an analysis in which volume regulation is assumed by the user for every planning period, differs from ARVOL output even when management assumptions are held constant and identical data are used for all planning periods.

Figure 2 shows the acres cut over the 180-year period with the SORAC volume regulation option. AREA assumes area regulation, but ARVOL assumes volume regulation. The area cut is less during the first rotation for SORAC after the initial planning period than for ARVOL because the volume cut is lower. Maximum deviation from the AREA trend line occurs with ARVOL because the old-growth timber is harvested faster than with the SORAC schedule. In SORAC, timber cut at the beginning of the second rotation is approximately 150 years old, whereas following the ARVOL schedule results in rotation-age timber being cut at that time.

One should be aware that using the area regulation option of SORAC for each planning period with constant parameter values will yield the same trend line as AREA, both for volume and acres cut.

In practice, SORAC generally would not be used in the manner indicated above. That is, parameters would not likely be held constant, and regulation method may change within a rotation. SORAC is a flexible planning tool into which managers may insert their expectations and which will provide implications of managerial action. Also, as noted earlier, SORAC is a computer model that simulates the allowable cut decision process used by many forest managers in the Pacific Northwest and other regions.

OPERATION OF THE SORAC COMPUTER PROGRAM

The SORAC program, when operated under the volume regulation option, prints only the final allowable cut and related data. The number of trial cuts required to arrive at the final cut is a function of the accuracy of the starting approximation of allowable cut, which is a required input to the program. The program begins at the cut level set by the user and converges toward the final allowable cut by an iterative procedure. When final cut is determined, it and associated outputs are printed and the program either continues into the data-update procedure, which develops input data, or new input data are read for the cut calculation appropriate to the next planning period.

When the area regulation option is used, no iteration procedure is required because the final cut is calculated directly. Once the cut is determined, the program either proceeds into the data-update procedure or reads new data, as it does with volume regulation.

Time requirements for a problem of any given size cannot be estimated with certainty because speed of solution is dependent upon the first approximation of allowable cut and the amount of input data. However, some typical operation times follow:

Number of stands	Regulation method	Rotation	Number of planning periods per rotation	Management level	Execution time[1]
		(Years)			(Minutes)
63	Volume	90	9	Extensive	2.31
30	Volume	90	9	Intensive	2.93
8	Area	80	8	Extensive	.23
63	Area	100	10	Extensive	.57
63	Mixed	100	10	Extensive	1.50

[1] Does not include compilation time. Time is for version 9, modification level 11, of the IBM 7040 Operating System. Also, SORAC is operational on the IBM 360/50 and CDC 6400 computing systems.

AVAILABILITY OF SORAC

Requests for the "User's Manual for SORAC Computer Program" (including source program listing) and FORTRAN IV source deck may be addressed to the Director, Pacific Northwest Forest and Range Experiment Station, P.O. Box 3141, Portland, Oregon 97208.